US007254458B2

(12) **United States Patent**
Hasan

(10) **Patent No.:** **US 7,254,458 B2**
(45) **Date of Patent:** ***Aug. 7, 2007**

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(54) **SYSTEMS AND METHODS FOR METROLOGY RECIPE AND MODEL GENERATION**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **11/471,992**

(22) Filed: **Jun. 21, 2006**

(65) **Prior Publication Data**

US 2006/0247818 A1 Nov. 2, 2006

Related U.S. Application Data

(63) Continuation of application No. 10/132,553, filed on Apr. 24, 2002, now Pat. No. 7,089,075.

(60) Provisional application No. 60/288,748, filed on May 4, 2001.

(51) **Int. Cl.**
G06F 19/00 (2006.01)

(52) **U.S. Cl.** **700/121**; 700/109

(58) **Field of Classification Search** 700/121, 700/108, 109–110; 702/83, 84
See application file for complete search history.

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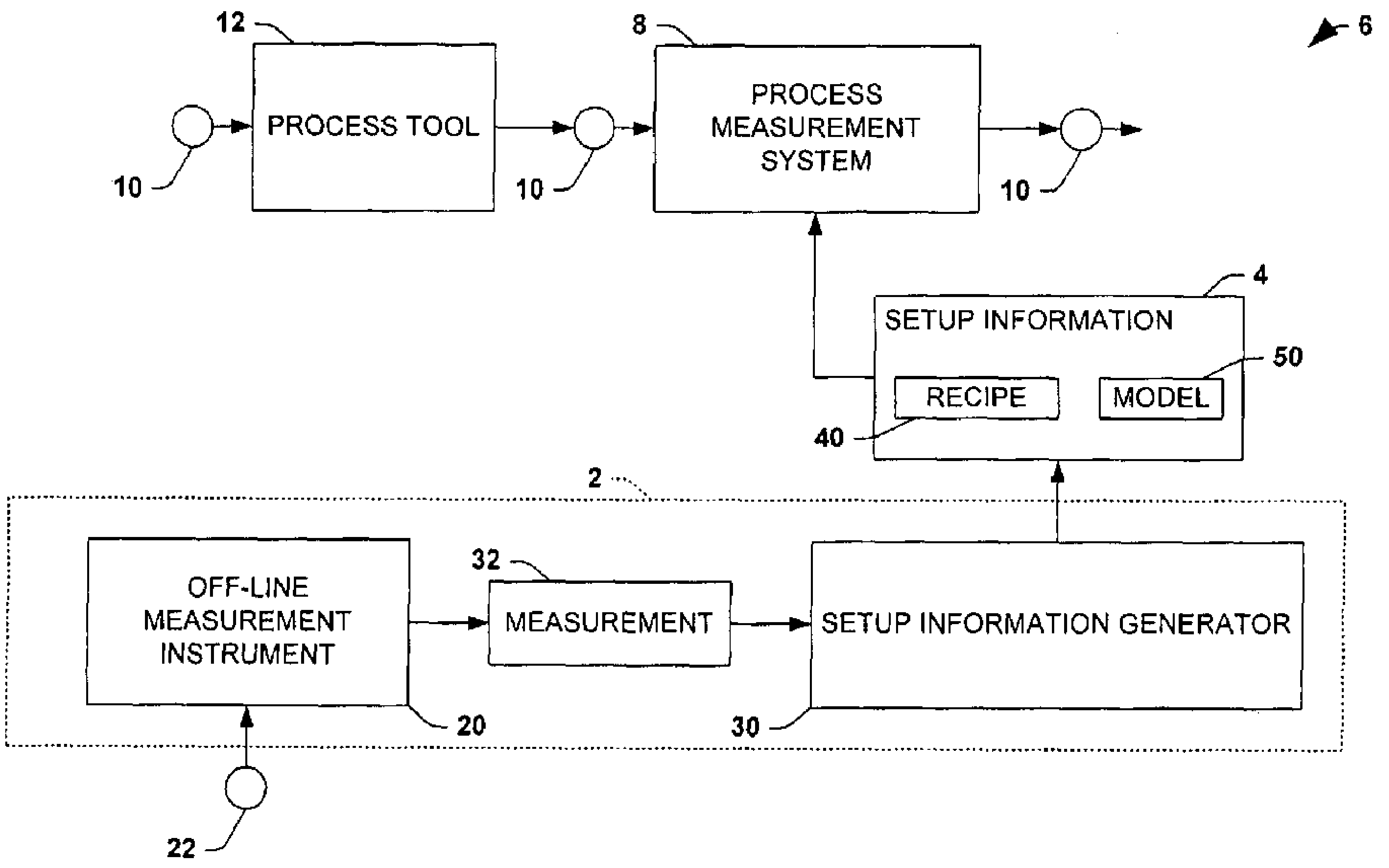
(57) **ABSTRACT**

Systems and methodologies are disclosed for generating setup information for use measuring process parameters associated with semiconductor devices. A system comprises an off-line measurement instrument to measure an unpatterned wafer and a setup information generator to generate setup information according to the unpatterned wafer measurement. The system then provides the setup information to a process measurement system for use in measuring production wafers in a semiconductor manufacturing process.

14 Claims, 11 Drawing Sheets



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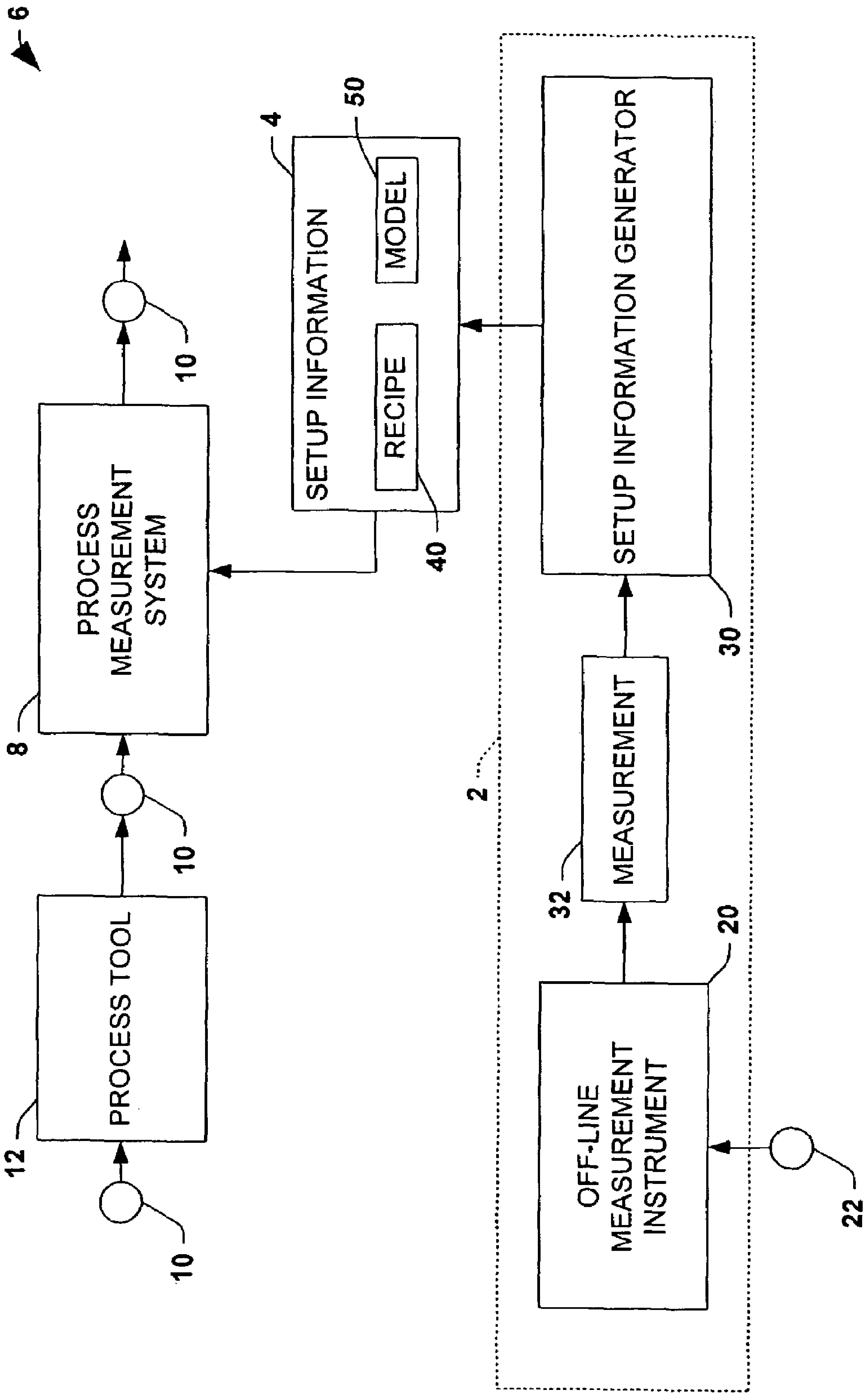
6
10
12
PROCESS TOOL
10
8
PROCESS MEASUREMENT SYSTEM
10
4
SETUP INFORMATION
RECIPE
40
MODEL
50
2
OFF-LINE MEASUREMENT INSTRUMENT
22
20
MEASUREMENT
32
SETUP INFORMATION GENERATOR
30

FIG. 1

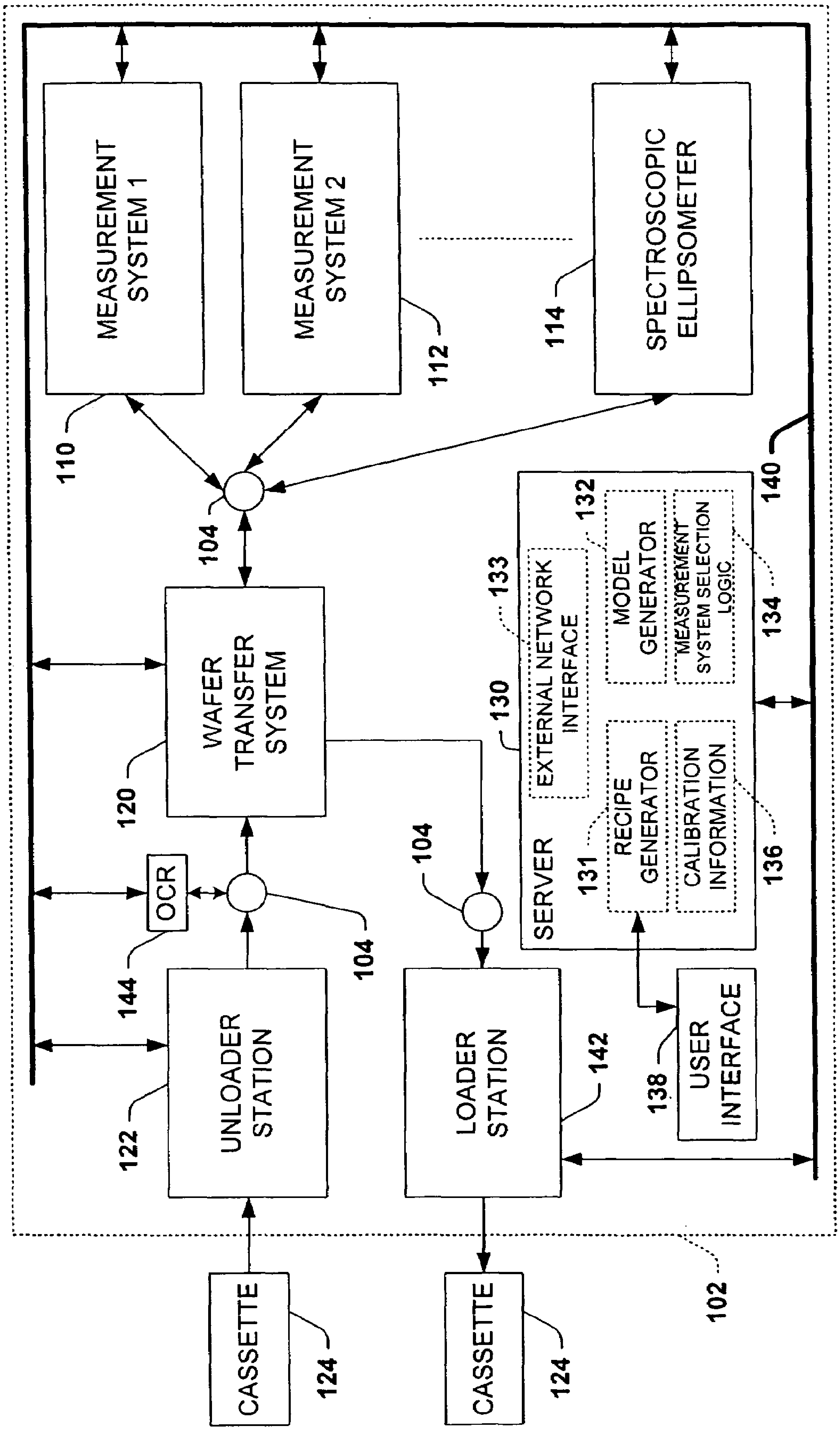
MEASUREMENT SYSTEM 1
110
MEASUREMENT SYSTEM 2
112
SPECTROSCOPIC ELLIPSOMETER
114
104
WAFER TRANSFER SYSTEM
120
OCR
144
104
UNLOADER STATION
122
104
LOADER STATION
142
SERVER
130
EXTERNAL NETWORK INTERFACE
133
RECIPE GENERATOR
131
MODEL GENERATOR
132
CALIBRATION INFORMATION
136
MEASUREMENT SYSTEM SELECTION LOGIC
134
USER INTERFACE
138
140
CASSETTE
124
CASSETTE
124
102

FIG. 2

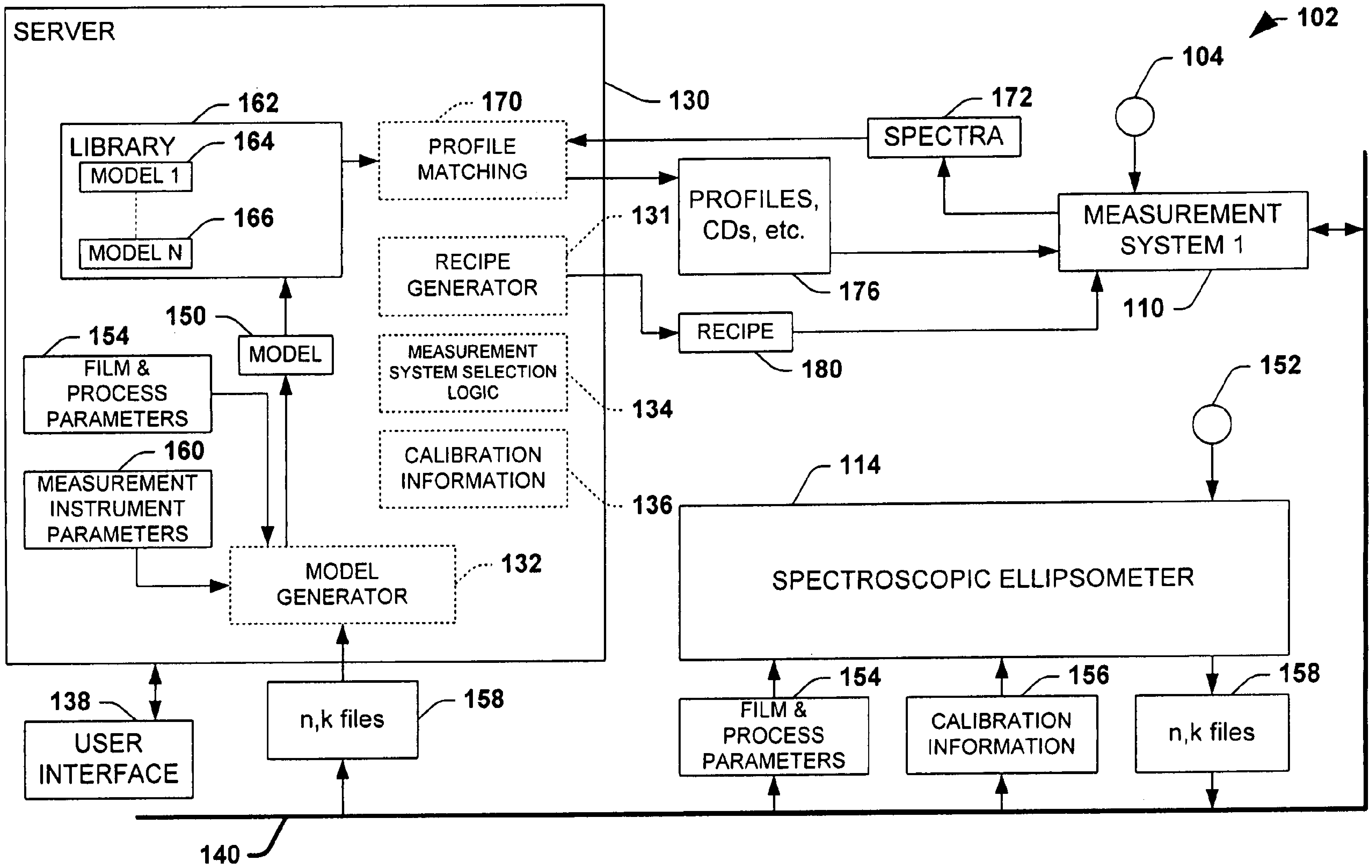
102
SERVER
130
162
LIBRARY
164
MODEL 1
166
MODEL N
170
PROFILE MATCHING
131
RECIPE GENERATOR
MEASUREMENT SYSTEM SELECTION LOGIC
134
CALIBRATION INFORMATION
136
150
MODEL
154
FILM & PROCESS PARAMETERS
160
MEASUREMENT INSTRUMENT PARAMETERS
MODEL GENERATOR
132
172
SPECTRA
PROFILES, CDs, etc.
176
RECIPE
180
104
MEASUREMENT SYSTEM 1
110
152
114
SPECTROSCOPIC ELLIPSOMETER
154
FILM & PROCESS PARAMETERS
156
CALIBRATION INFORMATION
158
n,k files
138
USER INTERFACE
n,k files
158
140

FIG. 3

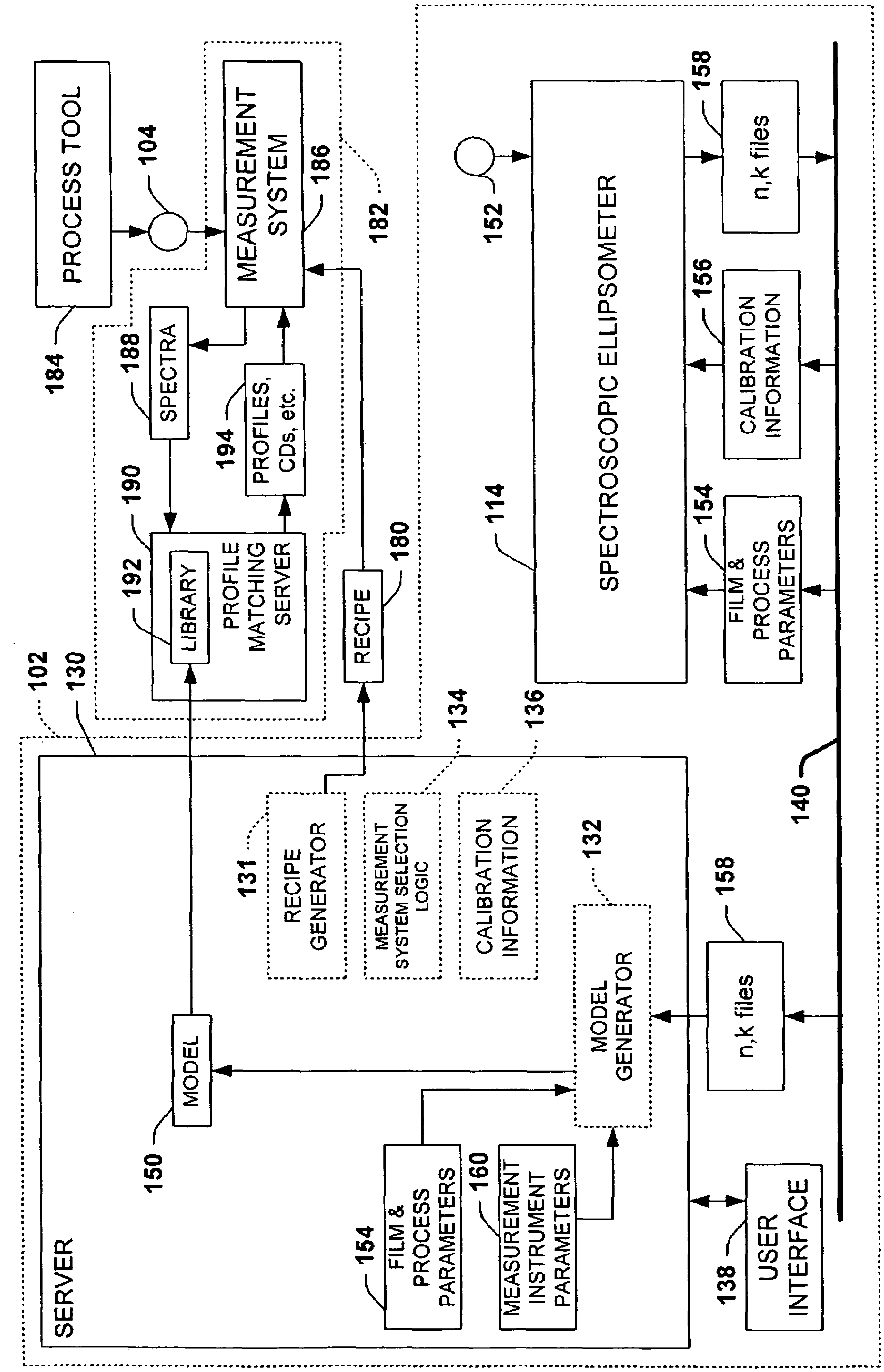
PROCESS TOOL
184
104
MEASUREMENT SYSTEM
186
182
SPECTRA
188
PROFILES, CDs, etc.
194
LIBRARY
192
PROFILE MATCHING SERVER
190
RECIPE
180
102
130
SERVER
RECIPE GENERATOR
131
MEASUREMENT SYSTEM SELECTION LOGIC
134
CALIBRATION INFORMATION
136
MODEL GENERATOR
132
MODEL
150
n,k files
158
FILM & PROCESS PARAMETERS
154
MEASUREMENT INSTRUMENT PARAMETERS
160
USER INTERFACE
138
140
SPECTROSCOPIC ELLIPSOMETER
114
152
n,k files
158
CALIBRATION INFORMATION
156
FILM & PROCESS PARAMETERS
154

FIG. 4

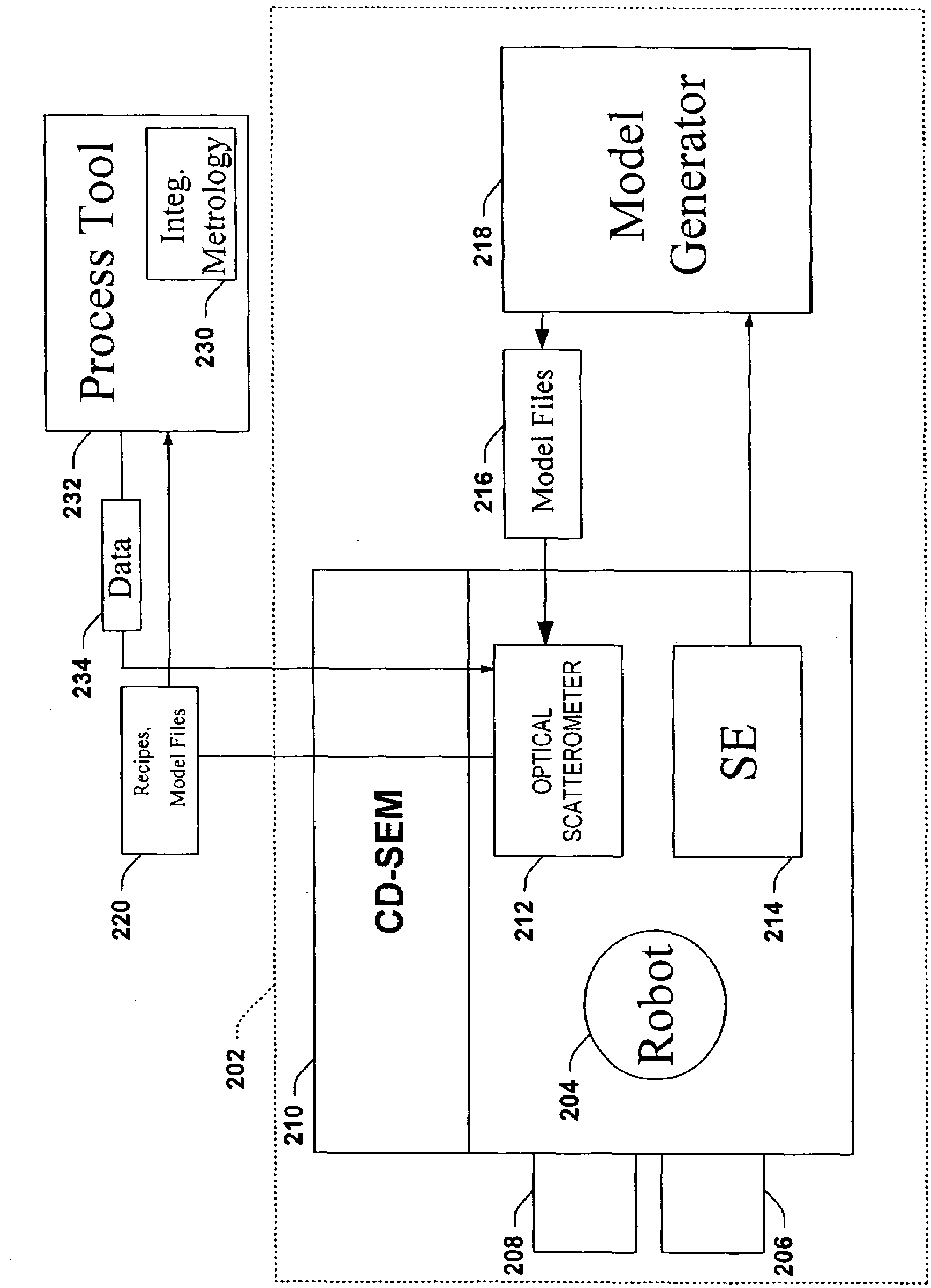
Process Tool
Integ. Metrology
230
232
Data
234
Recipes, Model Files
220
202
Model Generator
218
Model Files
216
CD-SEM
210
OPTICAL SCATTEROMETER
212
SE
214
Robot
204
208
206

FIG. 5

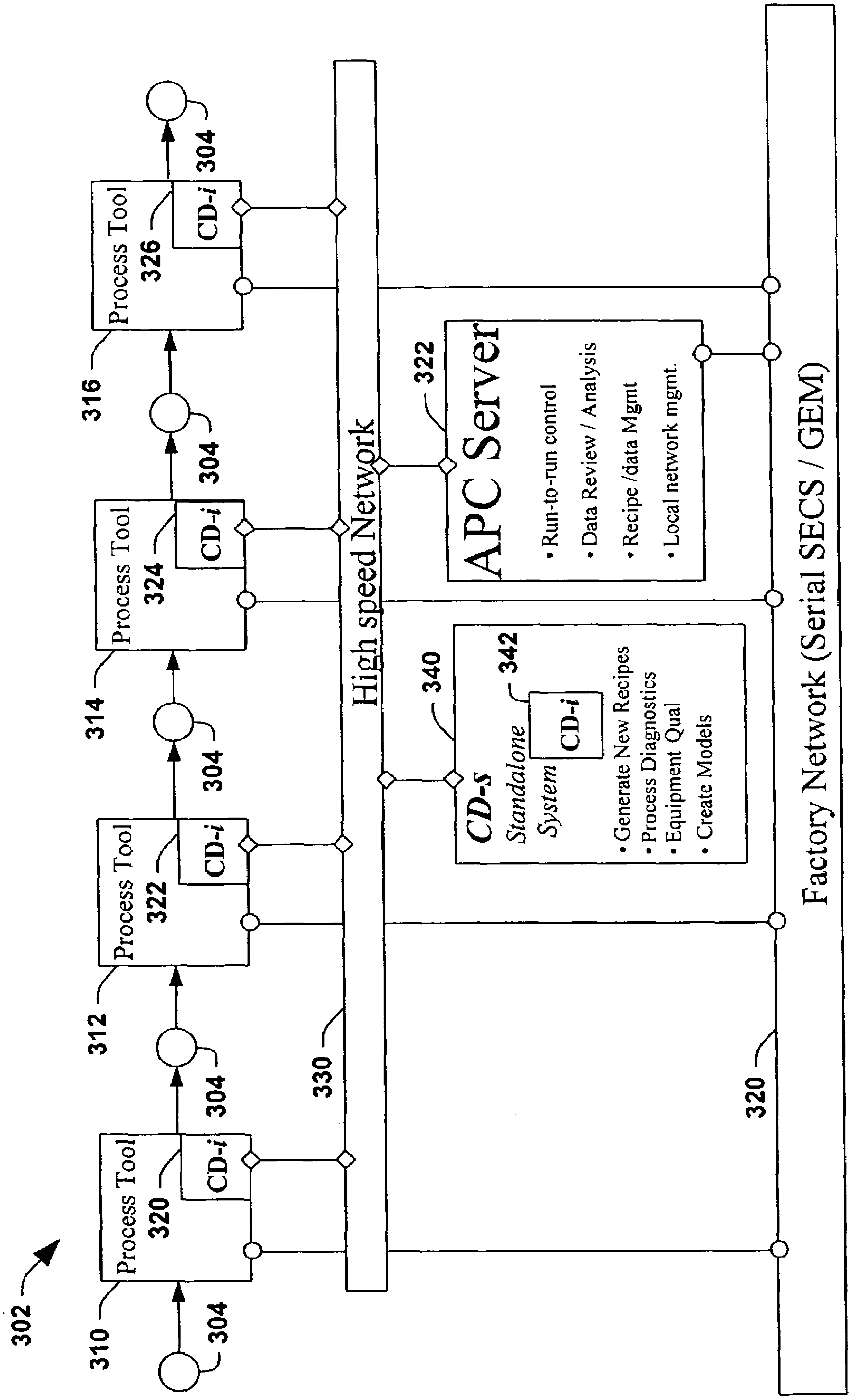
302
310
304
Process Tool
320
CD-i
312
304
Process Tool
322
CD-i
314
304
Process Tool
324
CD-i
316
304
Process Tool
326
CD-i
304
330
High speed Network
340
342
CD-s
Standalone
System
CD-i
• Generate New Recipes
• Process Diagnostics
• Equipment Qual
• Create Models
322
APC Server
• Run-to-run control
• Data Review / Analysis
• Recipe /data Mgmt
• Local network mgmt.
320
Factory Network (Serial SECS / GEM)

FIG. 6

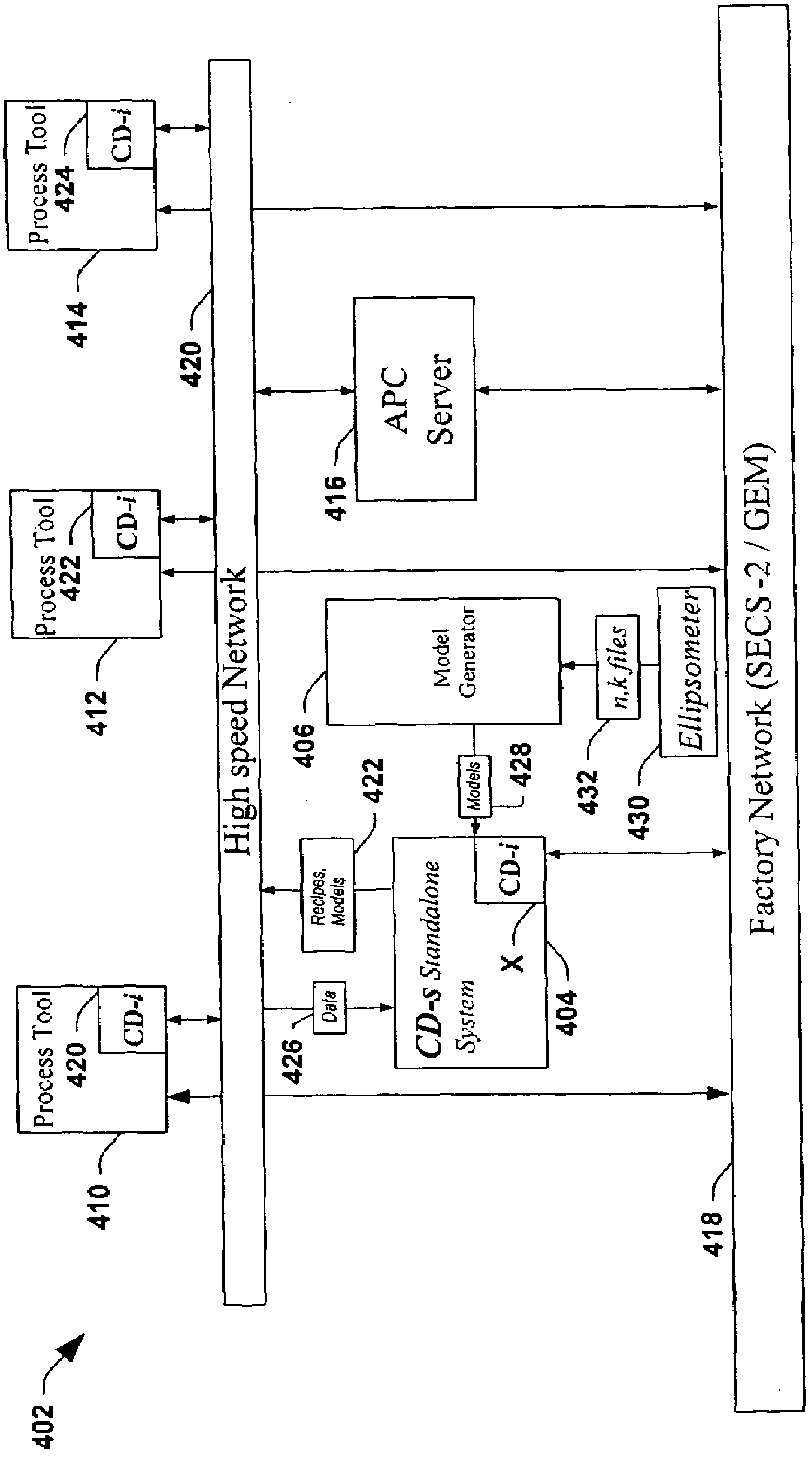
402
Process Tool
420
CD-i
410
Process Tool
422
CD-i
412
Process Tool
424
CD-i
414
High speed Network
420
Data
426
CD-s Standalone System
X
CD-i
404
Recipes, Models
422
Models
428
Model Generator
406
n,k files
432
Ellipsometer
430
APC Server
416
Factory Network (SECS-2 / GEM)
418

FIG. 7

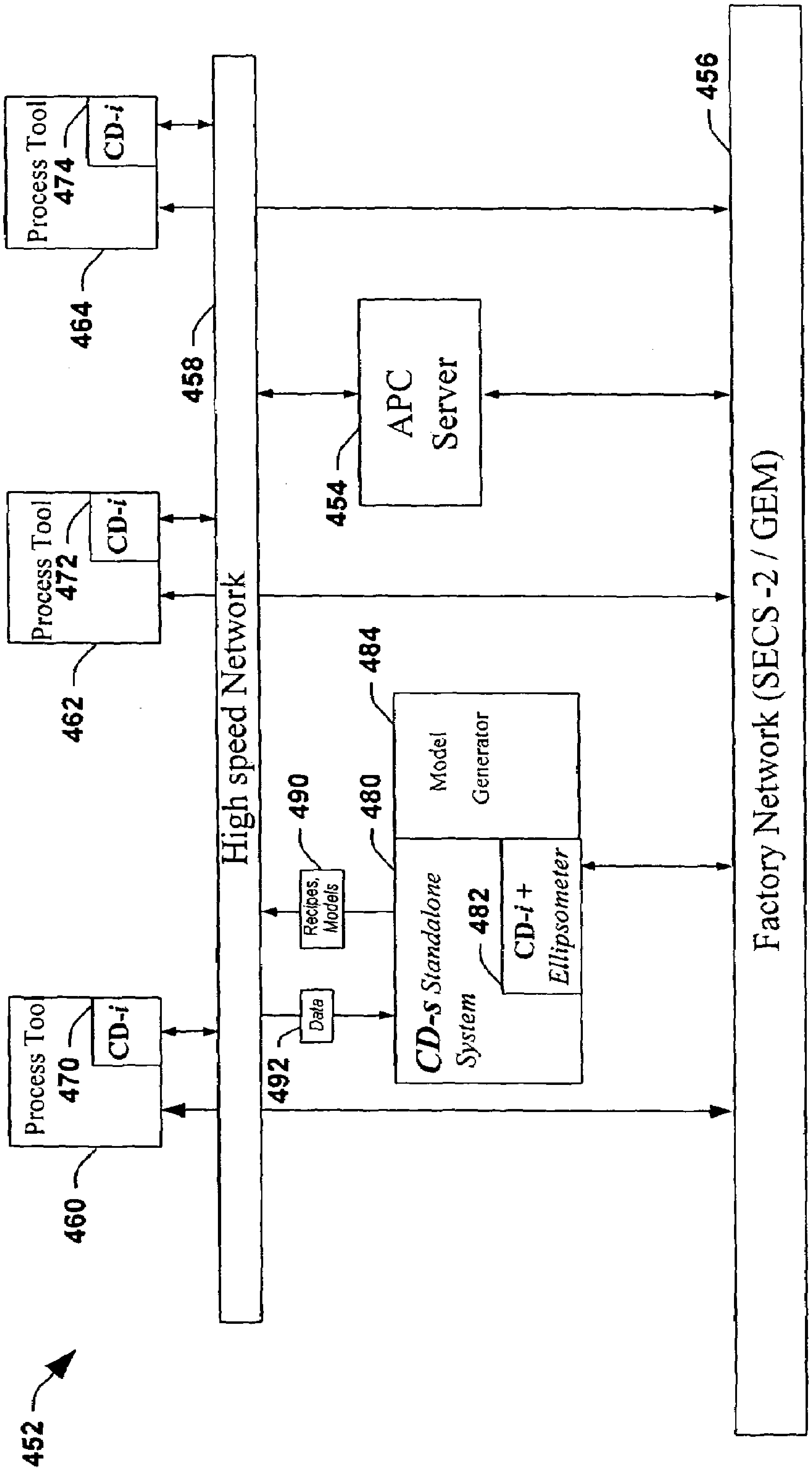
452
460
Process Too
470
CD-i
462
Process Tool
472
CD-i
464
Process Tool
474
CD-i
High speed Network
458
492
Data
490
Recipes, Models
480
CD-s Standalone System
482
CD-i + Ellipsometer
484
Model Generator
454
APC Server
Factory Network (SECS -2 / GEM)
456

FIG. 8

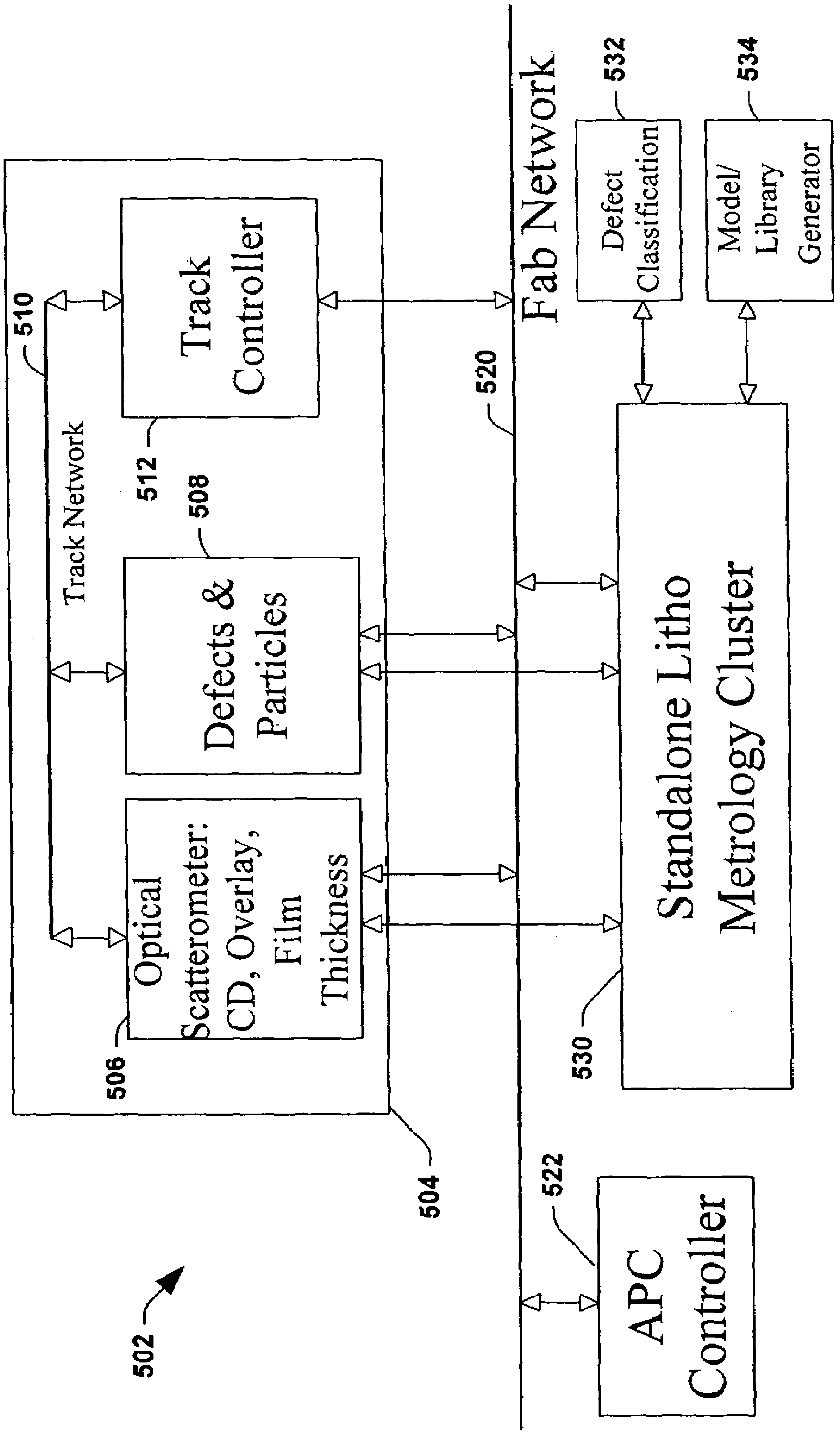
502
504
506
508
510
512
Track Network
Optical Scatterometer: CD, Overlay, Film Thickness
Defects & Particles
Track Controller
520
Fab Network
522
APC Controller
530
Standalone Litho Metrology Cluster
532
Defect Classification
534
Model/ Library Generator

FIG. 9

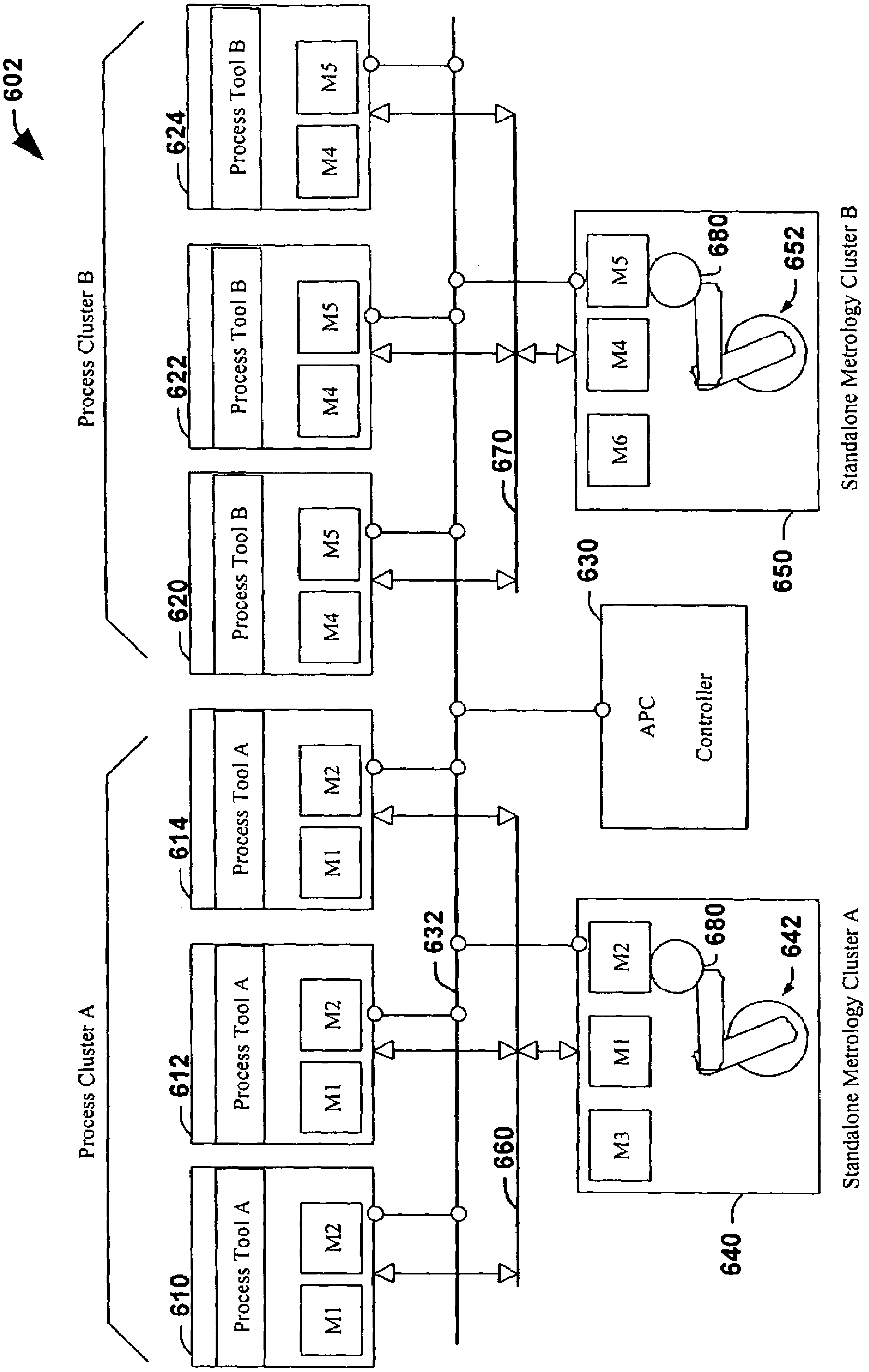
602
Process Cluster A
Process Cluster B
610
612
614
620
622
624
Process Tool A
Process Tool B
M1
M2
M3
M4
M5
M6
632
660
670
630
APC
Controller
640
650
642
652
680
Standalone Metrology Cluster A
Standalone Metrology Cluster B

FIG. 10

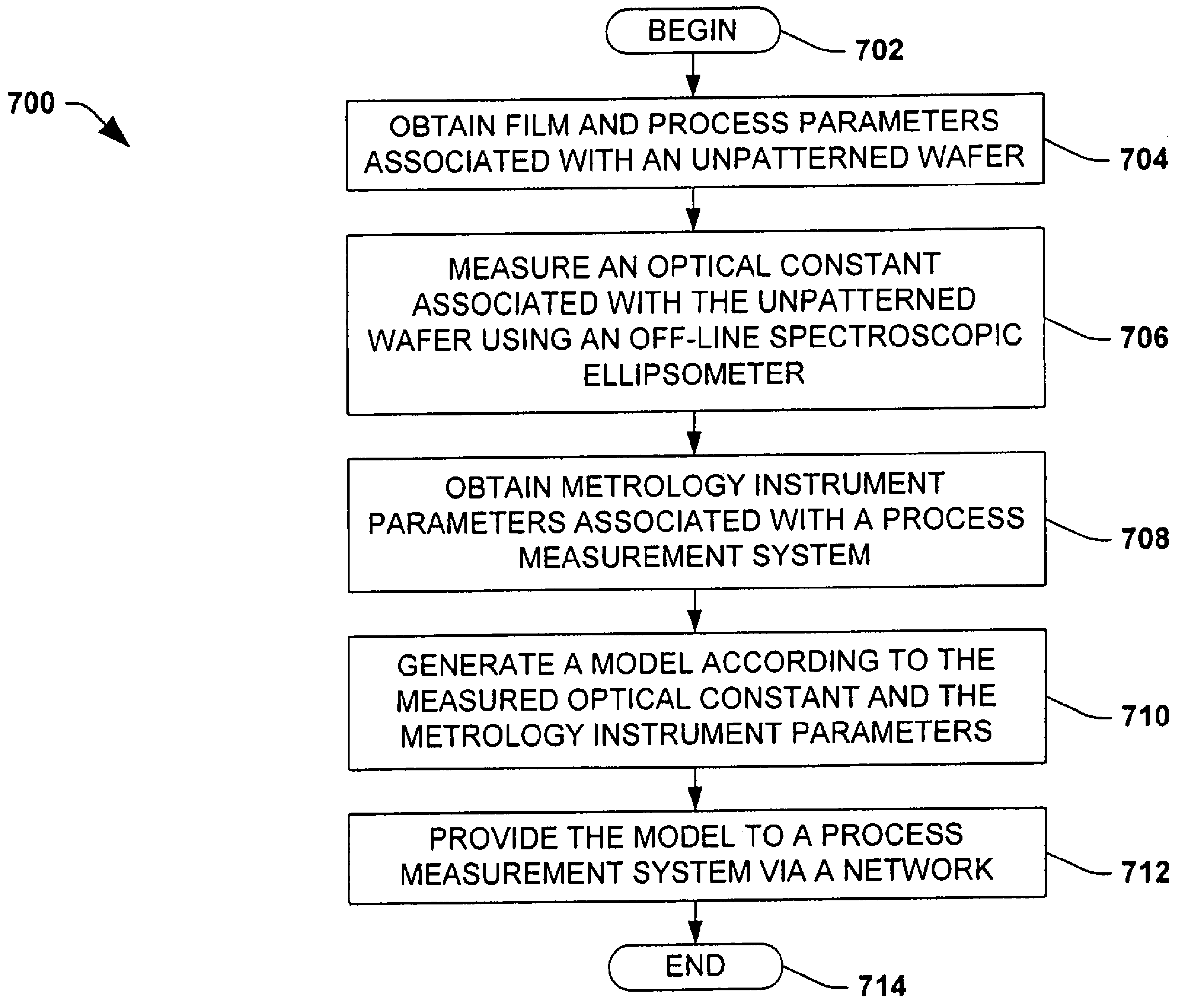
700
BEGIN
702
OBTAIN FILM AND PROCESS PARAMETERS ASSOCIATED WITH AN UNPATTERNED WAFER
704
MEASURE AN OPTICAL CONSTANT ASSOCIATED WITH THE UNPATTERNED WAFER USING AN OFF-LINE SPECTROSCOPIC ELLIPSOMETER
706
OBTAIN METROLOGY INSTRUMENT PARAMETERS ASSOCIATED WITH A PROCESS MEASUREMENT SYSTEM
708
GENERATE A MODEL ACCORDING TO THE MEASURED OPTICAL CONSTANT AND THE METROLOGY INSTRUMENT PARAMETERS
710
PROVIDE THE MODEL TO A PROCESS MEASUREMENT SYSTEM VIA A NETWORK
712
END
714

FIG. 11

SYSTEMS AND METHODS FOR METROLOGY RECIPE AND MODEL GENERATION

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of U.S. patent application Ser. No. 10/132,553, filed Apr. 24, 2002 now U.S. Pat. No. 7,089,075. This application also claims the benefit of U.S. Provisional Application Ser. No. 60/288,748, entitled "Systems And Method For Metrology Recipe And Model Generation" and filed on May 4, 2001, the entirety of which is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to the art of semiconductor device manufacturing and fabrication, and more particularly to optimized systems and methodologies for creating setup information for semiconductor device measurement systems.

BACKGROUND OF THE INVENTION

In the semiconductor industry there is a continuing trend toward higher device densities. To achieve these high densities there have been, and continue to be, efforts toward scaling down the device dimensions on semiconductor wafers. In order to accomplish such a high device packing density, smaller feature sizes are required. These may include the width and spacing of interconnecting lines and the surface geometry such as the corners and edges of various features. The requirement of small features with close spacing between adjacent features requires high-resolution photo-lithographic processes as well as high resolution metrology and inspection instruments and systems.

Lithography refers generally to processes for pattern transfer between various media. It is a technique used for integrated circuit fabrication in which, for example, a silicon wafer is coated uniformly with a radiation-sensitive film (e.g., a photoresist), and an exposing source (such as ultraviolet light, x-rays, or an electron beam) illuminates selected areas of the film surface through an intervening master template (e.g., a mask or reticle) to generate a particular pattern. The exposed pattern on the photoresist film is then developed with a solvent called a developer which dissolves either the exposed pattern or the complimentary unexposed pattern, depending on the type of photoresist (i.e., positive or negative resist). After developing, the wafer has a photoresist mask corresponding to the desired pattern on the silicon wafer for further processing.

In addition to lithographic processes, other process steps in the fabrication of semiconductor wafers require higher resolution processing and measurement equipment in order to accommodate ever shrinking feature sizes and spacing. Measurement instruments and systems are used to inspect semiconductor devices in association with manufacturing production line quality control applications as well as with product research and development. The ability to measure and/or view particular features in a semiconductor workpiece allows for adjustment of manufacturing processes and design modifications in order to produce better products, reduce defects, etc. For instance, device measurements of film thicknesses, critical dimensions (CDs), profiles, and overlay registration may be used to make adjustments in one or more such process steps in order to achieve the desired

product quality. Accordingly, various metrology and inspection tools and instruments have been developed to map and record semiconductor device features, such as scanning electron microscopes (SEMs), atomic force microscopes (AFMs), scatterometers, spectroscopic ellipsometers (SEs), and the like.

One particular type of measurement system is a scatterometer, which is different from conventional film measurements.. Scatterometry is a technique for extracting information about a structure or stacked structures upon which an incident light has been directed. In particular, scatterometry involves extracting information from gratings over other gratings or from gratings over a film stack. As indicated by its name, scatterometry is primarily concerned with the shapes of two and three dimensional structures in order to ascertain and determine the roughness of the layers or the non-planarity or non-parallelism of the planes. The structures of interest scatter light in ways that flat, one-dimensional layers do not. Process information concerning properties such as profile and critical dimensions of features present on and within the stacked structure can be extracted by employing a scatterometer. Using scatterometry, this information can be obtained by comparing measured and calculated signatures relating to the stacked structure. A signature may be defined as the phase and/or intensity of the light directed onto the surface of a wafer with phase and/or intensity signals of a complex reflected. and/or diffracted light resulting from the incident light reflecting from and/or diffracting through the surface upon which the incident light was directed.

Conventional film metrology involves treating volumes which are essentially one-dimensional, that is composed of layers such as sub-volumes separated by parallel planes. In scatterometry, the intensity and/or the phase of the reflected and/or diffracted light change according to properties of the stacked structure. Examples of such properties include the roughness of the layers and the non-planarity or non-parallelism of the subject plane(s) upon which the light is directed.

Different combinations of such properties will have different effects on the phase and/or intensity of the incident light resulting in substantially unique signatures in the complex reflected and/or diffracted light. Thus, by examining a database of calculated signatures or model of calculated signatures, a determination can be made concerning the properties of the stacked structure. For instance, a measured signature may be matched to a calculated signature, thereby yielding a measured profile of the stacked structure or a portion thereof. Such substantially unique signatures are produced by light reflected from and/or refracted by different surfaces due, at least in part, to the complex index of refraction of the surface onto which the light is directed.

The complex index of refraction (N) can be computed by examining the index of refraction (n) of the surface and an extinction coefficient (k). One such computation of the complex index of refraction can be described by the equation $N=n-jk$, where j is an imaginary number.

Generally, the n and k values for a given surface layer may be measured using a spectroscopic ellipsometer (SE), which may be used, in part, to generate such signature models in a semiconductor manufacturing endeavor. "Unpatterned wafer" means "an unpatterned portion of a wafer". Optical instruments, e.g., an SE or a scatterometer, have a "spot size" of some size which defines the region where the instrument is sensitive. If a wafer has regions which are essentially uniform ("unpatterned") as large as the spot size, those portions can be measured as "unpatterned" even though the wafer elsewhere has patterns, if the "spot" is placed on unpatterned on uniform regions. When exposed to a first incident light of known intensity, wavelength and phase, a first layer with a first chemical composition on a wafer can generate a first phase/intensity signature. Similarly, when exposed to the first incident light of known intensity, wavelength and phase, a second chemical composition on a wafer can generate a second phase/intensity signature. For example, a nitrided gate oxide layer with a first nitrogen concentration may generate a first signature while a nitrided gate oxide layer with a second nitrogen concentration may generate a second signature.

Observed signatures can be combined with simulated and modeled signatures to form the signal (signature) library. Simulation and modeling can be employed to produce signatures against which measured signatures can be matched, for instance, using a profile matching server or system. When phase/intensity signals are received from scatterometry detecting components, the phase/intensity signals can be pattern matched, for example, to the library models of signals, in order to determine whether the signals correspond to a stored signature.

Scatterometry may thus be advantageously employed in a semiconductor device manufacturing or fabrication process, in order to measure certain process parameters associated with individual processing steps therein. For example, a lithography process step may involve patterning wafers in order to create features thereon having certain critical dimensions (CDs), profiles, spacings, etc., wherein the overall quality of the resulting semiconductor device may depend on the accuracy of the lithography step. Scatterometry may be employed in order to verify such dimensional process parameters, as well as other process conditions, such as overlay registration, and the like. Today, such model generation is typically done remotely from the process and scatterometer with which the models are ultimately to be employed. In order to setup a scatterometer for use with a new or changed process step, such models must be obtained, along with recipes for performing one or more required measurements on processed wafers.

Obtaining models from such remote model generation sites sometimes takes days, during which time wafers processed according to the new process step cannot be measured using the scatterometer. In addition, the scatterometry measurement system may need to be trained in order to program new measurement recipes, during which time the scatterometer cannot be used to measure production wafers. Thus, the generation and/or creation of setup information such as models and recipes for use in measurement systems has heretofore resulted in significant process down-time. Accordingly, there is a need for improved methods and systems by which such setup down-time may be reduced or mitigated.

SUMMARY OF THE INVENTION

The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is intended to neither identify key or critical elements of the invention nor delineate the scope of the invention. Rather, the sole purpose of this summary is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented hereinafter.

The present invention provides systems and methodologies for generating setup information for use in determining process parameters associated with semiconductor devices. The systems may be employed off-line, that is, apart from an active, on-going semiconductor fabrication process, to generate setup information for downloading to active-process measurement tools, such that the active-process tools may be kept running during setup information generation. In addition, the systems, though off-line, may be interconnected to the active fabrication process via a bus configuration system, whereby measured and calculated information relating to a subject structure may be obtained by and shared with the active fabrication process system as well as other measurement systems and process tools as needed or desired. The bus configuration system allows for information to be available to the various connected measurement systems, tools and instruments almost immediately after the respective information becomes available. Furthermore, such systems may be networked with integrated measurement or metrology tools employed by the active fabrication process in order to improve the active fabrication process, such as setup information generation, defect classification, data acquisition, rendering of data to a user, cross-calibration of measurement instruments, and the like.

The setup information generation systems comprise an off-line measurement instrument to measure a wafer, and a setup information generator to generate models and/or recipes according to the wafer measurement. The setup information generation system then provides the setup information to an active process measurement system, such as an integrated measurement tool or instrument, for use in measuring production wafers in a semiconductor manufacturing process.

According to an aspect of the present invention, a system is provided for creating setup information for use in measuring process parameters associated with semiconductor wafers in a semiconductor device manufacturing process, which comprises an off-line measurement instrument adapted to measure a wafer and a setup information generator. The setup information generator is operatively connected to the off-line measurement instrument to create setup information according to a measurement therefrom. The setup information is then provided to a process measurement system associated with the semiconductor device manufacturing process. The setup information can include recipes and/or models usable by the active process measurement system to measure process parameters associated with semiconductor wafers moving through the semiconductor device manufacturing process.

As used in the present invention, a recipe is a set of instructions for a measurement instrument comprising where to measure on the wafer, measurement system parameters for the physical measurement, and specification of an algorithm or formula to convert the fundamental physical measurements into useful information. For example, for a reflectometer measurement instrument, the recipe may comprise information about the layout of the wafer including die size and location, which dies on the wafer to measure, one or more sites within the die at which to measure (e.g., one or more sites corresponding to structures in the die), pattern recognition parameters to identify and locate structures in the die, length of time to integrate over for measuring reflected intensities, wavelengths of light at which to report measured intensities, an algorithm or mathematical formula based on a model that comprises a stack of thin films at the measurement location, specification of which parameters are known and which are to be measured, and the like. Other information may also be included in the recipe, depending on the applicable measurement instrument and requirements of the user.

A model, according to the present invention, can be described as a physical structure (e.g., wafer or stack of film layers) having a set of boundaries or parameters associated therewith. For example, Model X**1** involves a structure B with a first set of parameters (e.g., 20 variables), whereby Model X**1** yields an optical response B**1** which may define a particular point in data space. Model X**2** involves the structure B but with a second set of parameters, which yield an optical response B**2**. The second set of parameters may include a variation of at least one of the 20 variables in the first set of parameters. A spectrum can be produced from each optical response, and the spectra taken from Models X**1** to Xn can be stored in a library. Spectra may be derived from either real wafer samples or from theoretical calculations.

Another aspect of the invention provides a method of generating setup information for measurement of process parameters associated with an active process measurement system in a semiconductor device manufacturing process. This aspect of the invention comprises performing a measurement of a wafer using an off-line measurement instrument, generating setup information according to the measurement using a setup information generator, and providing the setup information from the setup information generator to the process measurement system using a network. The measurement can comprise measuring an optical constant associated with a layer on the wafer using a spectroscopic ellipsometer, and the setup information generation may comprise generating a signature matching model for use in association with an optical scatterometer employing the optical constant from the spectroscopic ellipsometer.

According to yet another aspect of the invention, a system is provided for generating a model for use in matching measured spectra from an optical scatterometer with performance parameters associated with a processed semiconductor wafer. The system comprises a spectroscopic ellipsometer (SE) operative to measure optical constants associated with unpatterned portions of wafers and to provide a file of information relating to film parameters and process parameters associated with the unpatterned wafers and calibration information associated with the SE. The system further comprises a model generator receiving the file from the SE and operative to generate a model usable by a process measurement system according to the file, film and process parameters, and metrology instrument parameters associated with the process measurement system. In addition, the system comprises means for transferring the model to the process measurement system, such as a network.

Another aspect of the invention provides a system for measuring process parameters associated with semiconductor products in a semiconductor manufacturing process. The system comprises a first measurement instrument integrated into a process tool in the manufacturing process and a stand-alone measurement system having a second measurement instrument similar to the first measurement instrument. The stand-alone measurement system is operative to perform at least one support service for the first measurement instrument using the second measurement instrument, such as generation of setup information (e.g., measurement recipes, models, or the like), defect classification, data acquisition, rendering data to a user, and cross-calibration. The system further comprises a network, such as a high-speed TCP/IP network, operatively interconnecting the first measurement instrument in the process tool with the stand-alone measurement system, whereby information and data may be transferred therebetween.

To the accomplishment of the foregoing and related ends, certain illustrative aspects of the invention are described herein in connection with the following description and the annexed drawings. These aspects are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating an exemplary system for creating setup information in which one or more aspects of the present invention may be implemented;

FIG. **2** is a schematic diagram illustrating an exemplary stand-alone system for generating setup information in accordance with the invention;

FIG. **3** is a schematic diagram further illustrating the system of FIG. **2**;

FIG. **4** is a schematic diagram illustrating the stand-alone system of FIGS. **2** and **3** providing setup information to a process measurement system in accordance with another aspect of the invention;

FIG. **5** is a schematic diagram illustrating another exemplary stand-alone system providing setup information to an integrated metrology system in a process tool;

FIG. **6** is a schematic diagram illustrating a stand-alone system for creating setup information networked with several integrated metrology systems and an APC server via a high speed network in a semiconductor device manufacturing process;

FIG. **7** is a schematic diagram illustrating a stand-alone metrology system receiving models from an associated local model generator in accordance with another aspect of the invention;

FIG. **8** is a schematic diagram illustrating an exemplary stand-alone metrology system with integral ellipsometer and model generator in accordance with the invention;

FIG. **9** is a schematic diagram illustrating a stand-alone metrology cluster with associated defect classification and model generation systems networked to an integrated metrology system in a lithography process tool in accordance with another aspect of the invention;

FIG. **10** is a schematic diagram illustrating a portion of a manufacturing process having two process clusters with integrated metrology systems in process tools, and having networked stand-alone metrology clusters servicing the integrated metrology systems within the process clusters; and

FIG. **11** is a flow diagram illustrating an exemplary method of generating setup information in accordance with another aspect of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The various aspects of the present invention will now be described with reference to the drawings, wherein like reference numerals are used to refer to like elements throughout. The invention provides systems and methods for generating setup information, such as models and/or recipes, for use measuring process parameters associated with semiconductor devices. In one aspect of the invention, models and/or recipes are generated in a stand-alone measurement system networked to one or more in-process measurement systems. The stand-alone system may thus be used to perform setup type operations (e.g., model and/or recipe generation) in off-line fashion for subsequent downloading of such setup information to in-line process measurement systems. The invention may thus reduce or mitigate downtime associated with such setup operations.

Referring initially to FIG. **1**, an exemplary system **2** is illustrated for creating setup information **4** in association with a semiconductor device manufacturing process **6**, in which one or more aspects of the present invention may be implemented. The setup information **4** can be distributed to and employed by an active process measurement system **8** in measuring process parameters (e.g., CDs, profiles, overlay registration, and other process parameters) associated with semiconductor wafers **10** being processed by an integrated process tool **12** (e.g., lithography station or other process tool) in the manufacturing process **6**. The system **2** comprises an off-line measurement instrument **20**, such as a spectroscopic ellipsometer (SE), scanning electron microscope (SEM), atomic force microscope (AFM), scatterometer, or other type of measurement instrument, which is adapted to measure a wafer **22**. For instance, the instrument **20** may be an ellipsometer operative to measure optical constants such as n and k values associated with unpatterned portions of the wafer **22**. The system **2** further comprises a setup information generator **30** operatively associated with the instrument **20** to create the setup information **4** according to a measurement **32** therefrom, and to provide the setup information **4** to the active process measurement system **8**.

The setup information **4** can include any type of setup information usable by the active process measurement system **8**, such as for example, a recipe **40** and/or a model **50**. For instance, the model **50** may refer to a plurality of models (e.g., one or more models) such as Models X**1** to Xn. Each Model X**1** to Xn has the same physical structure but each has a different set of parameters associated therewith. The parameters may include one or more variables and each set of parameters may vary by as few as one variable. A calculated spectrum can be generated from each model which corresponds to a light-scattering pattern relating to the physical structure of the model and its given a set of parameters.

The calculated spectra derived from Models X**1** to Xn may also be referred to as calculated or theoretical signatures and stored in a signature library (e.g., intensity/phase signatures). The active process measurement system **8** compares a spectrum of a sample or unknown wafer **10**, which can be generated by a scatterometer, with signature library to find the closest match. This may be referred to as signature matching. Once the closest match is selected, the data associated with the closest match (e.g., stored signature of Model X**5**) is analyzed in order to "see" what structure was just measured. Additional models can then be generated by adjusting the parameters of Model X**5** in order to obtain an even closer match. The measurement system **8** may make a determination concerning the properties of the surface of the wafer **10**, such as the size, roughness, planarity, or spacing of features (e.g., lines) patterned thereon by the integrated process tool **12**. Thus, for example, measured signatures produced by light reflected from and/or refracted by different surfaces in the wafers **10** which are due, at least in part, to the complex index of refraction of the surface thereof, may be compared with theoretical signatures derived from the model **50**, whereby a process parameter (e.g., CD, profile, overlay registration, or other parameter) may be ascertained by the measurement system **8**, for example, using signature matching or other type of correlation technique. In this regard, the measurement **32** from the off-line instrument **20** can include the index of refraction (n) of the surface of the unpatterned wafer **22**, as well as an extinction coefficient (k).

The signature library can also be constructed in the setup information generator **30** from measured signatures of real samples such as the unpatterned wafer **22** and/or from calculated signatures generated by modeling and simulation. Measured signatures can be combined with calculated signatures to form the signature library. Thus, simulation and modeling can be employed to produce signatures in the model **50** against which measured signatures can be matched in the process measurement system **8**. It will be appreciated in this regard, that such simulation, modeling and/or measured signatures can be stored in a library (not shown) in the measurement system **8**, wherein the library can include many such measured and/or calculated signatures of known and unknown real samples. Thus, when the phase/intensity signals are received from scatterometry-detecting components in the system **8**, these can be compared to or otherwise correlated with the closest matching signature stored in the library.

In addition, the setup information may be transferred by any means, such as wherein the setup information generator **30** comprises a network interface (not shown) operative to transfer the setup information **4** to the process measurement system **8** via a network or bus configuration to facilitate immediate sharing of information between the various off-line and active measurement systems, instruments, and process tools, as illustrated and described in greater detail hereinafter. The system **2**, thus allows for off-line setup operations to be performed thereon, while the active process measurement system **8** may continue to actively measure wafers **10** with the integrated process tool **12**. In this manner, the invention may be advantageously employed to mitigate down-time associated with conventional setup information creation techniques.

According to another aspect of the invention, a setup information creation system may be implemented as a stand-alone automated system or cluster **102** as illustrated in FIG. **2**, comprising a cluster of measurement instruments or systems **110**, **112**, and **114** for measuring wafers **4**. The cluster **102** may be advantageously employed for measuring process parameters (e.g., overlay registration, photoresist layer defects, feature sizes, spacing between features, particle defects, chemical defects, film or layer roughness, and the like) associated with wafers **104** in a semiconductor fabrication process, as well as for generation of setup information for transferring to other measurement systems or measurement system clusters. The cluster **102** comprises a plurality of measurement systems **110**, **112**, and **114** having measurement instruments (not shown) associated therewith. For example, the systems **110** and **112** can include scanning electron microscopes (SEMs), atomic force microscopes (AFMs), scatterometers, or other measurement instruments adapted to measure process parameters associated with processed semiconductor wafers **104**, and the measurement system **114** is a spectroscopic ellipsometer (SE) in the exemplary cluster **102**.

The exemplary cluster **102** further comprises a wafer transfer system **120**, such as a robot or other automated wafer translation apparatus, which receives wafers **104** via an unloader station **122** which unloads wafers **104** from a cassette **124** or other wafer carrying device. Alternatively or in combination, wafers **104** can be provided to the wafer transfer system **120** (e.g., or individually to the measurement systems **110**, **112**, and/or **114**) manually. The wafer transfer system **120** operates to selectively provide wafers **104** to one or more of the measurement systems **110**, **112**, and/or **114** according to a measurement system selection criteria, such as wafer measurement throughput, measurement system accuracy capabilities,,measurement system availability, or other factors. One or more process parameters (e.g., CDs, profiles, overlay registration, or the like) are then measured and/or inspected in order to verify proper processing of the wafers and/or to detect defects or errors in the fabrication process. Furthermore, the measurement(s) from one or more of the measurement systems **110**, **112**, and/or **114** may be employed in order to generate setup information (e.g., recipes and/or models) for use in the cluster **102** or for provision to other measurement systems.

The exemplary cluster system **102** further comprises a server **130** having a recipe generator **131**, a model generator **132**, an external network interface **133** for transferring setup information (e.g., from the recipe generator **131** and/or the model generator **132**) to other measurement systems or instruments via an external network (not shown), a measurement system selection logic **134**, and calibration information **136** therein, as well as a user interface **138**. The user interface **138** may be used to obtain user information in generating recipes for measurement of process parameters in a process measurement system, as well as for rendering measurement data, statistics, or other report information from the cluster **102** to a user. For example, the server **130** may gather measurement data from the measurement systems **110**, **112**, and/or **114**, as well as from other networked measurement systems or instruments (e.g., via the external network interface **133**), which may then be formatted and presented to a user via the interface **138**. The measurement systems **110**, **112**, and **114**, as well as the unloader station **122**, the wafer transfer system **120**, and the server **130** are networked together via a network **140** internal to the cluster **102**, whereby measurement information, measurement system selection information, calibration information **136**, and other control information and data may be shared between the various components of the measurement system cluster **102**.

Once the appropriate process parameters associated with the wafers **104** have been measured via the measurement systems **110**, **112**, and/or **114**, the wafer transfer system **120** provides the wafers **104** to a loader station **142** which loads the wafers into outgoing wafer cassettes **124** for transfer to other systems in the fabrication process, such as a downstream process tool (not shown). One skilled in the art will recognize that the loader and unloader stations may be physically the same device, and that the incoming and outgoing cassettes may be the same. The cluster **102** preferably further comprises an optical character recognition (OCR) system **144** providing a wafer identification (not shown) to the measurement system selection logic component **134** via the network **140**, whereby the component **134** may make an appropriate selection of measurement system(s) **110**, **112**, and/or **114** to be used to measure or inspect the wafer **104**. Although the exemplary cluster **102** identifies the wafers **104** using the OCR system **144**, other techniques may be used to identify the wafers **104**, such as for example, location within the cassette **124**, or other methods as are known. It will be appreciated, however, that where lot code information, date codes, and the like are printed or stamped directly on the wafers **104**, the OCR system **144** can advantageously reduce the likelihood of incorrect wafer identification.

The measurement system selection logic component **134** in the server **130** provides a measurement system selection to the wafer transfer system **120** according to one or more selection criteria, wherein the wafer transfer system **120** provides the wafers **104** to at least one of the measurement systems **110**, **112**, and/or **114** according to the measurement system selection. For example, the measurement system selection criteria can include capabilities requirements information associated with the wafer **104**, as well as capability information, availability information, and throughput information associated with the measurement systems **110**, **112**, and **114**. The selection moreover, may be made according to a desired sequencing of measurements in the systems **110**, **112**, and/or **114**, for example, where the spectroscopic ellipsometer **114** is employed to measure optical constants or the like associated with an unpatterned wafer **104**, which constants are then provided to the model generator **132** in the server **130** via the internal network **140**, in order to generate a model.

The capabilities information may thus be derived according to the wafer identification from the OCR system **144**, and may comprise information indicating the type of feature(s) or dimension(s) to be measured in the system **102**, as well as the required accuracy for the measurement(s). The measurement system selection from the logic component **134** may further take into account the measurement capabilities of the various measurement systems **110**, **112**, and/or **114**. For example, one or more of the systems **110**, **112**, and/or **114** may be capable of performing a given measurement within the required accuracy, while others may not. In addition, the respective systems **110**, **112**, and/or **114** can each have different throughput capabilities. For instance, a SEM instrument may be able to measure 130 wafers per hour (wph), a scatterometer may measure up to 150 wph, and a spectroscopic ellipsometer may measure 75 to 80 wph. In selecting a measurement system to perform a given measurement task, therefore, the measurement system selection logic component **134** may advantageously select the system which can provide the highest throughput, within the required measurement capabilities for the measurement.

In this regard, the selection logic component **134** may also consider which systems **110**, **112**, and/or **114** are currently available in scheduling the, transfer of wafers **104** via the transfer system **120**. Thus, the measurement system selection logic component **34** provides the selection indicating a selected measurement system **110**, **112**, or **114** having capabilities required for the wafer **104** according to the capabilities requirements information (e.g., obtained or derived from the wafer identification via the OCR system **144**) and the measurement system capability information. Furthermore, the selection may reflect the measurement system having the highest throughput with the capabilities required for the wafer **104** according to the measurement system availability information and the throughput information.

As the various measurement systems **110**, **112**, and **114** are interconnected in the cluster **102**, and may share information via the network **140**, the systems **110**, **112**, and/or **114** may be cross-calibrated. In this regard, the calibration information **136** in the server **130** may be shared between the various systems **110**, **112**, and **114**, whereby the measurements made by one measurement instrument in the systems **110**, **112**, or **114**, are comparable to those made by another such instrument. In addition, such calibration may be provided to other measurement systems via the external network interface **133**, for example, whereby cross-calibration may be achieved between measurement instruments **110**, **112**, **114**, and other measurement systems outside the cluster system **102**. The exemplary cluster system **102** thus provides significant advantages over conventional stand-alone measurement systems with respect to cross-calibration as well as in reducing excess transferring of the wafers **104** between such stand-alone measurement stations in a fabrication process.

Information may be provided to an upstream (e.g., or downstream) process tool (e.g., photo-resist track, stepper, or the like), which can employ such information as process feedback, whereby on-line closed-loop process control can be achieved, for example, wherein the process tool performs fabrication processing steps according to the measurement data in order to mitigate defects in processed wafers **104**. Alternatively or in combination, the measurement (e.g., and/or defect detection) information may be provided to an advanced process control (APC) system (not shown), which in turn may provide process adjustments to such process tools in feedback and/or feed forward fashion. In this regard, it will be appreciated that the reduction in transfer time resulting from clustering of multiple measurement systems **110**, **112**, and **114** into a single system **102**, as well as the selective employment of appropriate measurement systems based at least in part on throughput and/or availability information, may be used to mitigate down-time of related process tools, whereby real-time or near real-time measurement and/or defect detection may be achieved with little or no fabrication process down-time, in accordance with the present invention. Moreover, the exemplary measurement cluster **102** may also be integrated with a process tool, as illustrated further hereinafter, which operates to perform one or more fabrication processing steps on the wafers **104** and to provide the processed wafers **104** to the wafer transfer system **120**.

Referring also to FIG. **3**, further details of the exemplary system **102** are illustrated, wherein the system **102** may be advantageously employed to perform model generation to create one or more models Z1 to Zn **150** using the model generator **132**. An unpatterned wafer **152** is provided to the SE **114** (e.g., manually or via wafer transfer system **120**), together with film and process parameters **154** associated with the processing of the wafer **152**, and calibration information **156** from the server **130**. The. ellipsometer **114** is then employed to measure the wafer **152** for providing n, k files **158** to the server **130** via the internal network **140**, for example, including the refractive index n and extinction coefficient k. The files **158** are then provided to the model generator **132** along with film and process parameters **154** and measurement instrument parameters **160**, which the model generator **132** uses to generate the model **150**. The model **150**, in turn, may be stored in a library **162** having N such models **164** through **166**. A signature matching component **170** in the server **130** thereafter may receive a measured spectrum **172** (or spectra) associated with a measured wafer **104** from a measurement system **110** (e.g., wherein system **110** can include a scatterometer), wherein the component **170** compares or correlates the measured spectra **172** to determine a performance parameter **176** (e.g., profiles, CDs, or the like) associated with the wafer **104**.

The cluster system **102** may alternatively or in combination be used to generate a recipe **180** via the recipe generator **131**, for use in making wafer measurements using the measurement system **110**. For instance, a user may train the system **102** via the user interface **138** for pattern recognition, selection of wafer sites to be measured, entry of acceptance limits, setting of alarm conditions, setting control limits for measured data, formatting for displaying or reporting measured data and/or statistics, destination to which measured data is to be sent, and the like. This recipe **180** may thereafter be used in measuring one or more wafers **104** using measurement systems **110**, **112**, and/or **114** in the cluster **102**, and/or may be transferred to other measurement systems via the external network interface **133** (e.g., FIG. **2**). The exemplary measurement system cluster **102** may thus provide significant advantages in performing setup operations such as model and/or recipe creation, wherein the setup tasks may be done in an off-line fashion while process measurement systems are used for measuring production wafers, thereby mitigating down-time associated with prior setup information generation techniques.

Referring now to FIG. **4**, the stand-alone system **102** can be used to provide setup information, such as recipe **180** and/or model Z1 to Zn **150**, to a separate and possibly remote process measurement system **182** receiving wafers **104** from a process tool **184** (e.g., lithography station or other process tool related to semiconductor device fabrication) in accordance with another aspect of the invention. The systems **102** and **182** may be operative to communicate with one another via a network (not shown) as illustrated and described in greater detail hereinafter, such as a high-speed TCP/IP network. The process measurement system **182**, moreover, can be of any type, including but not limited to another stand-alone cluster, an integrated metrology system within a process tool and having one or more measurement instruments or systems therein, or other apparatus operative to measure one or more process parameters associated with semiconductor wafers.

The process measurement system **182** comprises one or more measurement systems **186**, such as a scatterometer providing measured spectra **188** to a signature matching server **190** with a library **192** of models. The signature matching server **190** in the process measurement system **182** correlates the measured spectra with the models in the library **192** in order to determine one or more process parameters **194**, such as profiles, CDs, overlay registration, or the like. The setup information generation system **102** may advantageously create one or more models **150** for transfer to the process measurement system **182**, whereby the model **150** may be added to the library **192** in the signature matching server **190**, where it will be available for use in the process measurement system **182** as the need arises in the course of processing of wafers **104** using the process tool **184**. Alternatively or in combination, the setup information generation system **102** may be used to generate a measurement recipe **180**, which may also be provided to the measurement system **186** in the process measurement system **182**. Such recipes **180** and/or models **150** can also be replicated from a database (not shown) in the server **130** to any number of networked process measurement systems or instruments, whereby the stand-alone system **102** may operate as a centralized data store for such setup information.

The database may also contain information to facilitate conversion of the measured information collected by an instrument into useable information about the process state of the wafer **104**. For example, partial results of lengthy mathematical calculations and algorithms may be stored in a database for later, accelerated use. Measurement systems and metrology clusters described throughout FIGS. **1-4** above and FIGS. **5-11** below can generate databases to facilitate the determination and identification of wafer structures in accordance with the present invention. For further description of the database approach, pending U.S. application Ser. No. 09/927,177 (Publication No. 2002/0038196 A1) entitled "Database Interpolation Method For Optical Measurement of Diffractive Microstructures" is hereby incorporated by reference.

Referring now to FIG. **5**, another exemplary system **202** is illustrated for creating setup information in accordance with the invention. As with the exemplary system **102** of FIGS. **2**-**4**, the system **202** comprises a plurality of measurement instruments clustered together, with a robot **204** to transfer wafers (not shown) between one or more of the instruments and loading and/or unloading stations **206** and **208**, respectively. The system comprises a scanning electron microscope (CD-SEM) **210**, an optical scatterometer **212**, and a spectroscopic ellipsometer (SE) **214** located so as to allow transfer of wafers thereto from the robot **204**. It should be appreciated that optical scatterometer **212** may comprise spectroscopic ellipsometer **214**. In addition, the optical scatterometer **212** may also comprise a reflectometer (not shown).

The system **202** also comprises a model generator **218** and can be operated in similar fashion to the system **102** with respect to generating models **216**. For instance, the SE **214** may be employed to measure an unpatterned wafer (not shown), and may provide one or more optical constants (e.g., n, k files) to the model generator **218**, which in turn provides one or more model files **216** to the scatterometer **212**. The scatterometer **212** includes a signature matching system (not shown), which may be used to match measured spectra from production wafers (not shown) with theoretical signatures from the model files **216** in order to measure and/or determine one or more process parameters associated therewith. Alternatively or in combination, the model files **216** may be provided to an integrated metrology system **230** in a process tool **232** in accordance with another aspect of the invention.

The system **202** may also be used to generate measurement recipes for use in association with one or more of the measurement instruments **210**, **212**, and/or **214** therein. Such recipes and model files **220** can furthermore be transferred to a process measurement system, such as the integrated metrology system **230** in the process tool **232**. The cluster system **202** may also be provided with data **234**, such as measurement data, statistics, etc., from the process tool **232** and/or from the integrated metrology system **230** therein, whereby a user (not shown) may access such data (e.g., together with data from other networked process measurement systems associated with the system **202**) from a centralized location at the cluster **202**, without having to visit each such process measurement system individually. In this regard, the system **202** may comprise a user interface (not shown) allowing the user to interface therewith for obtaining such data, generating measurement recipes, and other operations. It will farther be appreciated in this regard, that the provision of the system **202** allowing such access to the associated process measurements (e.g., from the integrated metrology system **230**) may advantageously eliminate the need for such user interfaces at the process measurement systems.

Referring now to FIG. **6**, a portion of an exemplary semiconductor device manufacturing process **302** is illustrated, wherein semiconductor wafers **304** are successively processed by process tools **310**, **312**, **314**, and **316**. The process tools **310**, **312**, **314**, and **316** have integrated measurement or metrology systems or instruments **320**, **322**, **324**, and **326** integrated therein, respectively, for measuring one or more process parameters associated with the wafers **304**, such as CDs, overlay registration, profiles, or the like, in order to ascertain the quality of the wafers **304**, the accuracy of the process tools **310**, **312**, **314**, and/or **316**, or otherwise to verify proper processing of the wafers **304** in the process **302**. The process tools **310**, **312**, **314**, and **316** are connected to a factory network **320** for communication with each other as well as with an advanced process control (APC) server **322**, which can provide control of the tools **310**, **312**, **314**, and/or **316**, data acquisition therefrom, data review and analysis functions, network management functions, as well as providing a data store for various processing recipes used by the tools **310**, **312**, **314**, and/or **316**.

The integrated measurement systems **320**, **322**, **324**, and **326** are networked together via a high-speed network, such as a TCP/IP network **330** in order to communicate with each other and with a stand-alone measurement system **340** having one or more measurement systems **342** integrated therein. The standalone system **340** is operable to generate (e.g., and/or edit) measurement recipes usable by the process measurement systems **320**, **322**, **324**, and **326**, as well as to create models for use by the measurement systems in the process **302**, in a manner similar to the systems described above. In this regard, the system **340** includes measurement instruments **342** of the same or similar type as those for which the system **340** provides such support services. Thus, where the integrated measurement systems **320**, **322**, **324**, and **326** each comprise a CD-SEM and a scatterometer, the stand-alone system **340** also includes a CD-SEM and a scatterometer, thereby allowing the stand-alone system **340** to be used for off-line generation or creation of setup information (e.g., recipes and/or models) for use in the integrated measurement systems **320**, **322**, **324**, and/or **326**.

In addition, the stand-alone system **340** may be adapted to provide diagnostics services to the process **302**, for example, wherein measurement data from- one or more of the measurement systems **320**, **322**, **324**, and **326** are analyzed in order to identify process anomalies or defects in the wafers **304**. Furthermore, the system **340** may include a data store for measurement recipes and models used by the measurement systems **320**, **322**, **324**, and **326**, as well as for calibration information (not shown) related thereto. Thus, the standalone system **340** provides for cross-calibration of the various measurement systems **320**, **322**, **324**, and/or **326**, as well as the measurement system **342** integrated therein.

Referring now to FIG. **7**, another implementation of the invention comprises a stand-alone metrology system **404** receiving models from an on-site local model generator **406** associated therewith in a semiconductor device manufacturing process **402**. The process **402** comprises process tools **410**, **412**, and **414** networked to each other as well as to an APC server **416** via a factory network **418**. The process tools comprise integrated measurement systems or instruments (e.g., which may be clusters of instruments) **420**, **422**, and **424**, respectively, operative to measure process parameters associated with wafers (not shown) processed by the tools **410**, **412**, and/or **414** in a manner similar to the systems described hereinabove. The measurement systems **420**, **422**, and **424** are networked to each other as well as to the stand-alone system **404** via a high-speed network **420** for transfer of information therebetween. For instance, the network **420** advantageously provides for transfer of setup information (e.g., models and/or recipes) **422** from the stand-alone system **404** to one or more of the measurement systems **420**, **422**, and **424** in accordance with the present invention. In addition, data **426** may be transferred from one or more of the measurement systems **420**, **422**, and **424** to the stand-alone system **404** via the network **420**.

The stand-alone system may be employed to generate models **428** using an associated model generator **406** and an ellipsometer **430** providing n,k files **432** thereto, and may but need not include an associated profile and/or signature matching server (not shown). The model generator **406** can include one or more servers or computer systems, which receive the n,k files **432** and generate the models **428** in accordance therewith, for example, wherein an unpatterned wafer (not shown) is measured using the ellipsometer **430** in order to produce the n,k files **432**. Such models **428** and recipes **422** may then be uploaded to one or more process measurement systems **420**, **422**, and/or **424** via the network **420** for use thereby in order to measure one or more process parameters associated with wafers in the process **402**.

Another implementation of the present invention is illustrated in FIG. **8**, wherein an exemplary semiconductor wafer fabrication process **452** comprises process tools **460**, **462**, and **464** networked together with an APC server **454** via a factory network **456**, wherein the process tools **460**, **462**, and **464** respectively comprise integrated process measurement systems or tools **470**, **472**, and **474** networked via a high-speed network **458**, wherein the APC server **454** can also interact with the network **458**. A stand-alone measurement system **480** with interfaces to both networks **456** and **458** includes one or more integrated metrology or measurement systems or instruments **482** in similar fashion to the stand-alone system **102** illustrated and described above with respect to FIGS. **2-4**, as well as an integrated model generator **484**.

In addition to measurement systems or instruments of the same or similar type as the systems **470**, **472**, and **474** in the process tools **460**, **462**, and **464**, respectively, the integrated measurement system **482** in the stand-alone system **480** comprises an ellipsometer adapted to measure unpatterned wafers (not shown) in order to provide optical constants (e.g., n,k files) to the model generator **484**. Models and/or measurement recipes **490** may then be transferred to one or more of the integrated process measurement systems **470**, **472**, and/or **474** via the network **458**, and data **492** may be obtained therefrom by the stand-alone system **480**. Moreover, such measurement recipes, models, and other setup information may be replicated into a data store in the APC server **454** after receipt in the measurement systems **470**, **472**, and/or **474**, where such replication may be performed via either of the networks **456** or **458**.

Referring now to FIG. **9**, one or more aspects of the present invention may be applied to a lithography track type process tool **504** as part of a semiconductor device fabrication or manufacturing process **502**. Although illustrated and described herein with respect to a lithography process tool, it will be appreciated that the invention finds application in association with any processing steps in such a manufacturing process, and that such applications are deemed to fall within the scope of the invention. The process tool **504** includes components (not shown) for performing one or more lithography steps to wafers in the process **502**, as are known. In addition, the tool **504** comprises an integrated optical scatterometer measurement instrument **506** for measuring process parameters such as CDs, overlay registration, film thicknesses, profiles, or the like. The tool **504** further includes an inspection component **508**, whereat wafers may be inspected for defects and particulate matter. The scatterometer **506** and the inspection component **508** are networked via a track network **510** together with a track controller **512**, which provides for controlled operation of the tool **504**.

The track controller **512**, inspection component **508**, and the scatterometer **506** are operatively connected with a fabrication network **520** along with an APC controller **522**, which operates in similar fashion to the APC servers illustrated and described above. The measurement and inspection systems **506** and **508** are further networked with a stand-alone metrology cluster **530** having an associated defect classification system **532** and library or model generator system **534**. The cluster **530** includes a scatterometer (not shown) similar or identical to the scatterometer **506** in the track tool **504**, whereby the cluster may be used to create measurement recipes therefor while the scatterometer **506** is otherwise available for measuring wafers in the process **502**, which recipes may then be transferred to the process scatterometer **506**. Once received in the scatterometer **506**, such recipes may then be replicated to a measurement recipe data store (not shown) in the APC controller **522**.

The cluster **530** further comprises a spectroscopic ellipsometer (not shown) cooperating with the model generator **534**, whereby models may be generated in the cluster **530** for uploading to and use by the process scatterometer **506**. Data from one or both of the process scatterometer **506** and/or the inspection component **508** may be transferred to the cluster **530**, for analysis, detection, and/or diagnosis of one or more defects using the defect classification system **532**. It will be appreciated that the various functions described for the cluster **530**, as well as the other setup information creation systems and devices herein may be implemented in software executing on a server or other computer system or groups of such systems, or may be implemented in hardware or combinations of hardware and software, within the scope of the present invention. In this regard, the defect classification systems **532** and/or the model generator system **534** may comprise software in a server in the cluster **530**, or may reside in individual servers within the cluster **530**, or in other such integrated or associated implementations.

Data from the integrated metrology tool **506** can be advantageously employed in a variety of ways in order to identify proper performance of the track process tool **504**. For instance, critical dimension (CD) data that is collected by an integrated metrology system such as the scatterometer **506** in the track **504** can be analyzed with the data collected from a variety of other devices in order to deconvolve the various sources of CD uniformity. Such analysis may be performed in either of the stand-alone cluster **530** and/or the APC controller **522**. As one example, the temperature uniformity of each bake plate (not shown) in the track **504** can be mapped using a sensor wafer such as those available from Sensarray or On Wafer Technologies. When the CD is mapped using an integrated CD tool such as scatterometer **506**, this uniformity is a function of the bake-plate uniformity as well stepper dose uniformity and possibly resist thickness uniformity. The integrated measurement instrument **506** may be used to measure two of these three process parameters associated with a wafer, and the data analysis (e.g., in the cluster **530** and/or the APC controller **522**) may comprise deducing the stepper dose uniformity from measurement data for the bake plate uniformity and resist thickness. Thus, data from the integrated metrology tool **506** can be used for advanced process control (APC) functions.

Referring now to FIG. **10**, another aspect of the present invention provides for integration of one or more measurement instruments or systems in a process tool, where the measurement system or systems are networked to a stand-alone measurement system with a similar or identical measurement instrument. The stand-alone measurement system can thus provide support services for the integrated instrument(s), such as generation of setup information (e.g., measurement recipes, models, or the like), defect classification, data acquisition and reporting for rendering to a user, cross-calibration, and the like. A semiconductor device manufacturing process **602** is illustrated in FIG. **10**, having two process clusters, process cluster A and process cluster B, each process cluster having like process tools associated therewith.

Process cluster A comprises three process tools **610**, **612**, and **614** of type "A", for example, such as lithography tools. The type A tools **610**, **612**, and **614** in process cluster A each comprise integrated measurement instruments of types M1 and M2, for instance, wherein M1 may be a CD-SEM type measurement instrument, and M2 may be an optical scatterometer type. Many forms of measurement instrument integration are contemplated within the present invention, including but not limited to physical integration of such instruments within a process tool enclosure, attachment thereto, or other integration techniques. In addition to physical integration, the integrated measurement instruments or systems may be interconnected with such process tools so as to allow communication of information and/or data therebetween. The measurement instruments M1 and M2 integrated into the type A process tools **610**, **612**, and **614** are selected so as to accommodate measurements associated with the wafer processing performed by the type A process tools **610**, **612**, and **614**.

Similarly, process cluster B comprises three process tools **620**, **622**, and **624** of type "B", each having process measurement instruments or systems of type M4 and M5 selected according to the processing performed by the type B tools **620**, **622**, and **624**. For instance, the type B process tools **620**, **622**, and **624** may comprise etch tools. The integrated measurement instruments M1, M2, M4, and/or M5 may comprise individual measurement instruments, or alternatively may comprise clusters of similar or dissimilar measurement instruments within the scope of the present invention. The process tools **610**, **612**, **614**, **620**, **622**, and **624** are operatively interconnected with each other and with an APC controller **630** via a factory network **632** for communication of information and/or data therebetween. For instance, the APC controller may provide control information, process recipes, calibration information, or the like to the tools **610**, **612**, **614**, **620**, **622**, and **624**, and may receive measurement information or other information therefrom.

Stand-alone measurement system or metrology clusters **640** and **650** are operatively associated with the integrated measurement instruments-of the process tools in process clusters A and B via local cluster networks **660** and **670**, respectively, as well as via the factory network **632**. The stand-alone cluster **640** comprises measurement instruments (e.g., or clusters) M1 and M2 which are of the same or similar type (e.g., CD-SEM and scatterometer, respectively) as the instruments M1, and M2 integrated with the process tools **610**, **612**, and **614** of process cluster A, such that the metrology cluster **640** may provide one or more support services to the integrated measurement instruments or systems within the process cluster A.

In addition, the stand-alone cluster **640** includes a measurement instrument of type M3, and a wafer transfer system or robot **642** operative to selectively provide wafers **680** to one or more of the instruments M1, M2, and/or M3 therein. For instance, the M3 instrument can be a spectroscopic ellipsometer operative to measure optical constants associated with the wafers **680**, whereby a model generator (not shown) in the cluster **640** may create models for use in the scatterometers M1 of the process tools **610**, **612**, and/or **614** of the process cluster A, in a manner similar to that described above with respect to FIG. **3**. Alternatively or in addition, the cluster **640** may perform other support services for the integrated metrology devices in the tools **610**, **612**, and/or **614**, including but not limited to generation of other setup information (e.g., measurement recipe creation), defect classification, data acquisition, rendering data to a user, cross-calibration, or the like.

Similarly, a stand-alone measurement system cluster **650** is operatively associated with the measurement instruments M4 and M5 in the process tools **620**, **622**, and **624** of process cluster B via another local network **670**, and well as via the factory network **632**. The cluster B **650** comprises measurement instruments M4 and M5 of the same or similar type as the instruments M4 and M5 integrated in the process tools **620**, **622**, and **624**, whereby support services may be provided to the integrated instruments using the stand-alone system **650**, such as generation of setup information (e.g., model creation, measurement recipe creation, etc.), defect classification, data acquisition, rendering data to a user, cross-calibration, or the like. Also, the cluster system **650** comprises a robot **652** operational in a fashion similar to the robot **642** of cluster **640**.

Referring now to FIG. **11**, another aspect of the invention provides methods for generating setup information for measurement of process parameters associated with a process measurement system in a semiconductor device manufacturing process. The invention comprises performing a measurement of a wafer using an off-line measurement instrument, generating setup information according to the measurement using a setup information generator, and providing the setup information from the setup information generator to the process measurement system using a network.

An exemplary method **700** is illustrated in accordance with the present invention beginning at **702**. Although the exemplary method **700** is illustrated and described herein as a series of blocks representative of various events and/or acts, the present invention is not limited by the illustrated ordering of such blocks. For instance, some acts or events can occur in different orders and/or concurrently with other acts or events, apart from the ordering illustrated herein, in accordance with the invention. Moreover, not all illustrated blocks, events, or acts, may be required to implement a methodology in accordance with the present invention. In addition, it will be appreciated that the exemplary method **700** and other methods according to the invention can be implemented in association with the apparatus and systems illustrated and described herein,,as well as in association with other systems and apparatus not illustrated or described.

At **704**, film and process parameters associated with an unpatterned wafer are obtained, and an optical constant associated with the unpatterned wafer is measured at **706** using an off-line spectroscopic ellipsometer. At **708**, metrology instrument parameters associated with a process measurement system are obtained. Thereafter, a model is generated or created at **710** according to the measured optical constant and the metrology system parameters. Finally at **712**, the model is provided to a process measurement system via a network before the method ends at **714**.

Although the invention has been shown and described with respect to certain illustrated implementations, it will be appreciated that equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described components (assemblies, devices, circuits, systems, etc.), the terms (including a reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., that is functionally equivalent), even though not structurally equivalent to the disclosed structure, which performs the function in the herein illustrated exemplary aspects of the invention. In this regard, it will also be recognized that the invention includes a system as well as a computer-readable medium having computer-executable instructions for performing the acts and/or events of the various methods of the invention.

In addition, while a particular feature of the invention may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. As used in this application, the term "component" is intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution. For example, a component may be, but is not limited to, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and a computer. Furthermore, to the extent that the terms "includes", "including", with, "has", "having", and variants thereof are used in either the detailed description or the claims, these terms are intended to be inclusive in a manner similar to the term "comprising."

What is claimed is:

1. A method of evaluating parameters of a semiconductor wafer as part of a manufacturing process comprising the steps of:

measuring a plurality of reference wafers with an off-line scatterometer;

determining the parameters of the reference wafers based on the measurements;

using a model and the results of the determining step, to generate a library of calculated signatures, each corresponding to a different parameter set;

measuring a test wafer with a integrated scatterometer, said integrated scatterometer being integrated with a process tool; and

comparing the results of the measurement of the test wafer to the library of signatures to evaluate the parameters of the test wafer.

2. A method as recited in claim **1**, wherein the parameters include critical dimensions.

3. A method as recited in claim **1**, wherein the parameters include overlay registration.

4. A method as recited in claim **1**, wherein the parameters include the temperature uniformity of a bake process step.

5. A lithograph track processing apparatus comprising:

a stand-alone scatterometer, said scatterometer for measuring reference wafers and based on the measurements generating information corresponding to one of a measurement recipe and a library of signatures corresponding to parameter sets; and

a scatterometer integrated with a lithographic track processing tool, said integrated scatterometer for measuring a test wafer and evaluating process parameters of the test wafer using the measurement of the test wafer and said information received from the stand-alone tool.

6. An apparatus as recited in claim **5**, wherein the parameters include critical dimensions.

7. An apparatus as recited in claim **5**, wherein the parameters include overlay registration.

8. An apparatus as recited in claim **5**, wherein the parameters include the temperature uniformity of a bake process step.

9. An apparatus as recited in claim **5**, wherein said stand-alone scatterometer and said integrated scatterometer are connected by a network.

10. A lithograph track processing apparatus comprising:

a stand-alone scatterometer, said scatterometer for measuring reference wafers and using the measurements and a model, to generate a library of calculated signatures each corresponding to a different parameter set; and

a scatterometer integrated with a lithographic track processing tool, said integrated scatterometer for measuring a test wafer and evaluating process parameters of test wafer based on the measurement of the test wafer and the library received from the stand-alone scatterometer.

11. An apparatus as recited in claim **10**, wherein the parameters include critical dimensions.

12. An apparatus as recited in claim **10**, wherein the parameters include overlay registration.

13. An apparatus as recited in claim **10**, wherein the parameters include the temperature uniformity of a bake process step.

14. An apparatus as recited in claim **10**, wherein said stand-alone scatterometer and said integrated scatterometer are connected by a network.

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